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Abstract

PHYSICS OF FAST REACTORS

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Methods used in the study of the physics of fast reactors are reviewed with emphasis on advances made in the U.S. since 1958. Areas considered are: microscopic cross sections; multigroup constants and methods; statics; sodium void coefficient; and Doppler effect.

Recent advances in the knowledge of nuclear cross sections pertaining to fast reactor applications are reviewed and summarized. Experimental results discussed include: a) the differential elastic and transport cross sections of a wide range of elements extending from Al to U; b) detailed inelastic excitation cross sections; c) fast neutron capture inclusive of fissile materials; and d) fission properties particularly $\bar{\nu}$ and $d\bar{\nu}/dE$. Theoretical models are employed to interpret and extend the experimental results. In particular, recent advances in the optical model of neutron scattering and the theory of neutron induced reactions are employed.

A new 26 energy group set of multigroup constants, based on the latest microscopic data, has been generated. The heavy element constants are composition independent except for the region below 40 keV where resonance self shielding effects are included. The light and medium element transport and elastic transfer cross sections are composition dependent and are obtained from a many group fundamental mode calculation. The composition independent values of the multigroup constants are tabulated for some key materials (U-235, U-238, Pu-239) as are some typical composition dependent multigroup constants.

A set of fast critical assemblies is selected so as to cover the range of compositions and sizes studied experimentally to date. Various diluents (U-238, Al, Fe) and fuels (U-235, U-233, Pu-239) are included. Comparison is made for this set between calculations, based on the latest microscopic cross section data, and experimental results.

The dependence of the various components of the sodium void coefficient of plutonium fueled reactors on reactor size and composition is studied. The positive spectral effect is considerably increased by the presence of Pu-240, fission products, and certain refractory metals. It appears possible to compute the spectral and capture components of the sodium coefficient with a fundamental mode calculation, for which many groups may be used. The leakage component can be obtained with fewer groups. Available comparisons of calculated and measured sodium reactivity effects are presented.

While considerable uncertainties in resonance parameters exist for fissile isotopes, it does not appear that serious errors in Doppler effect calculations for large fast reactors will be caused thereby. The main contribution to the Doppler effect comes from the fertile isotopes, for which the parameters are reasonably well known. Effects studied and not found to present serious problems are the following: multilevel rather than single level fitting for fissile materials; the non-Maxwellian distribution of nuclear velocities; the temperature profile across a fuel rod; and heterogeneity effects. An improved method, which allows for proper averaging over resonance parameter distributions, has been developed for calculating overlap effects in fissile isotopes and overlap between fertile and fissile isotopes. The improved method is accurate for energies down to several hundred eV.